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(71) Applicant(s) Hitachi, Ltd. (Incorporated in Japan) 6 Kanda Surugadai, 4 - chome, Chiyoda-ku, Tokyo, Japan	(56) Documents Cited GB 2202387 A GB 1009372 A US 5291358 A US 4955791 A
(72) Inventor(s) Kazuhiro Kawakami Hisanobu Kanemaru	(58) Field of Search UK CL (Edition Q) H2A AKJ1 AKJ1A INT CL ⁶ H02K 5/167 ONLINE:WPI,JAPIO,EPODOC; OPTICS:H2A
(74) Agent and/or Address for Service Mewburn Ellis York House, 23 Kingsway, LONDON, WC2B 8HP, United Kingdom	

(54) Thrust bearing arrangement in a spindle motor

(57) The spindle motor according to the invention has a hub (1) and a shaft (2) concentrically disposed inside the inner circumference of a stator core, in which the shaft is borne by a bearing holding means through a bearing metal. The lower end of the shaft is made in a curved form and is borne by a pivot bearing of a bowl-like shaped thrust bearing (5) fastened to the bearing holding means 3. The foregoing bowl-like shaped thrust bearing is fastened into a stepped part of the bearing holding means against a stopper plate 6, the resilient inner edge of the stopper plate being snapped into a groove 2b formed on the shaft to axially retain the shaft.

FIG. 1

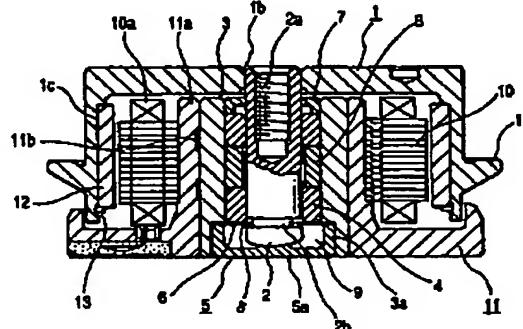
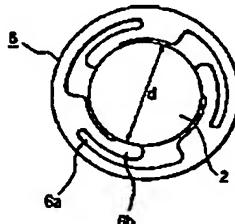


FIG. 2



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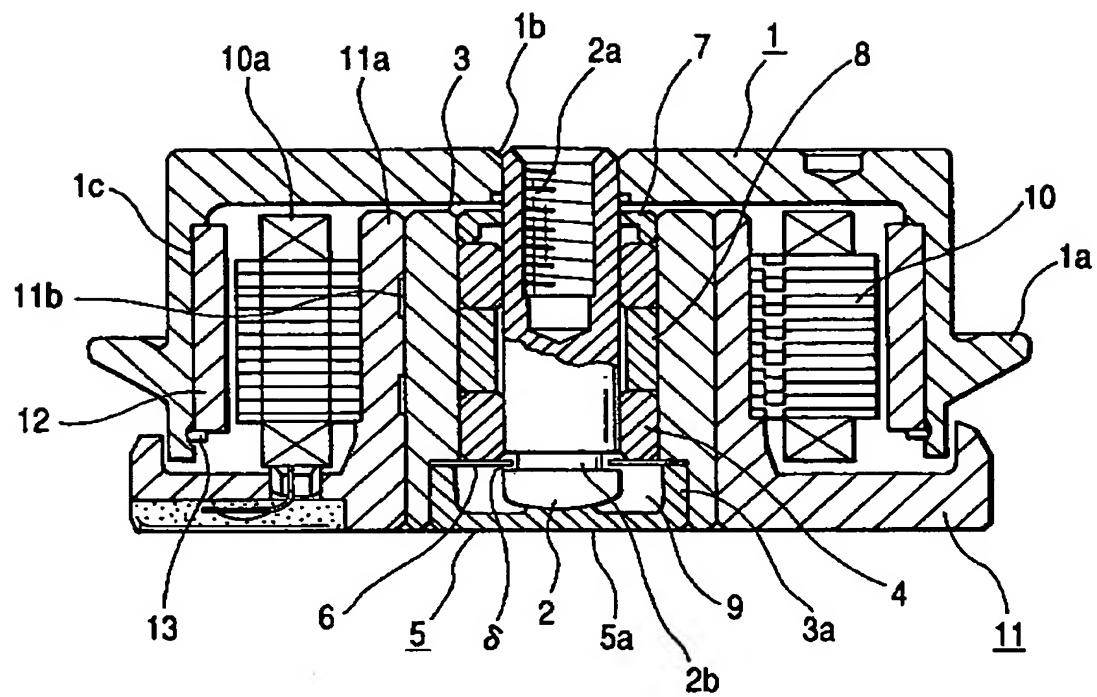
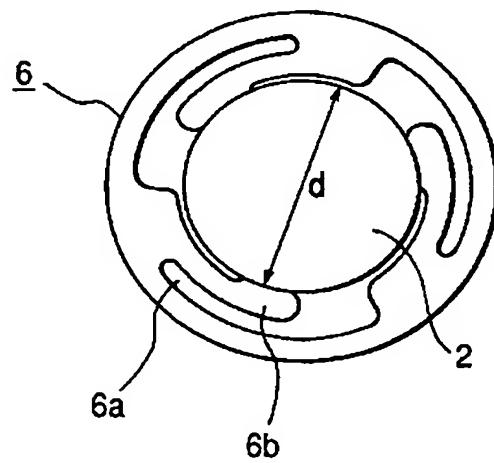
FIG. 1*FIG. 2*

FIG. 3

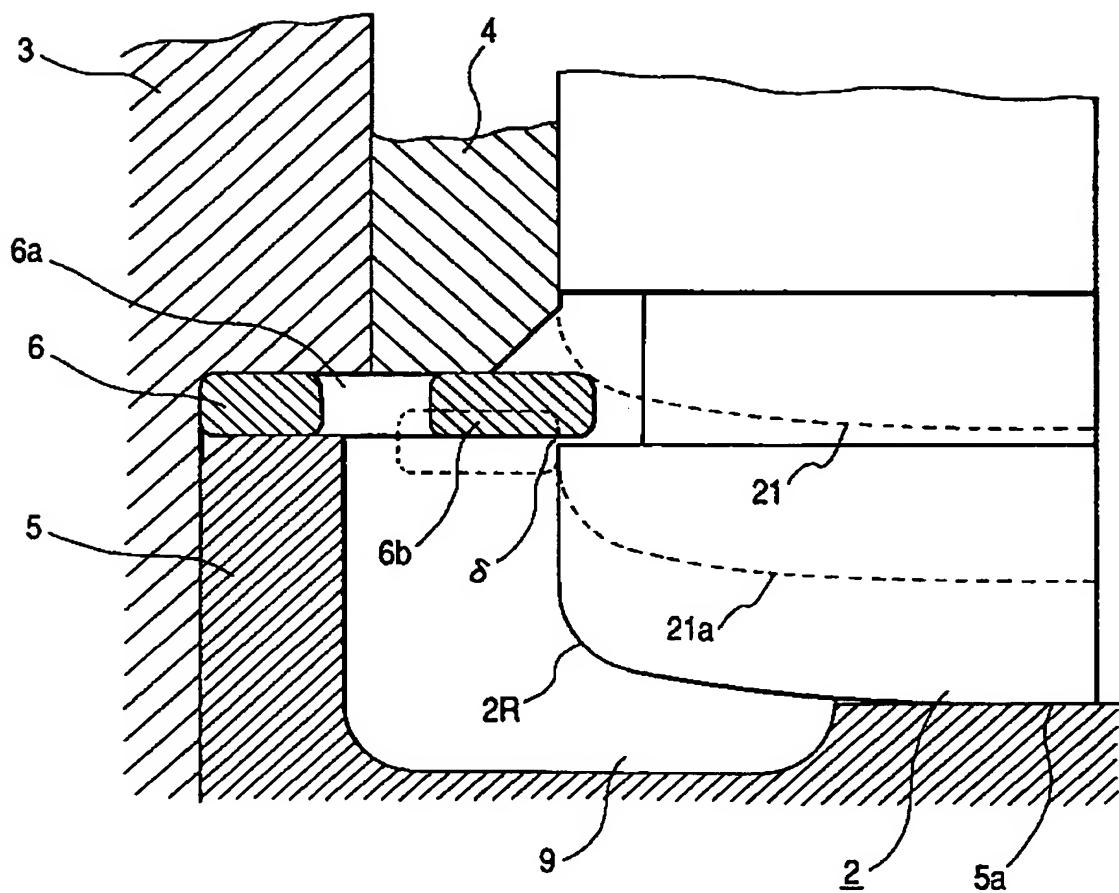


FIG. 4

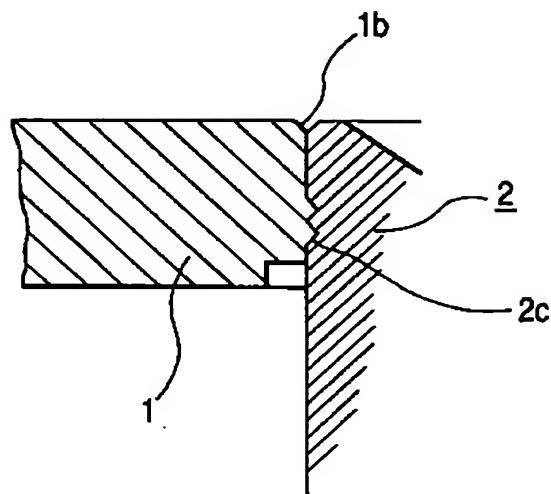
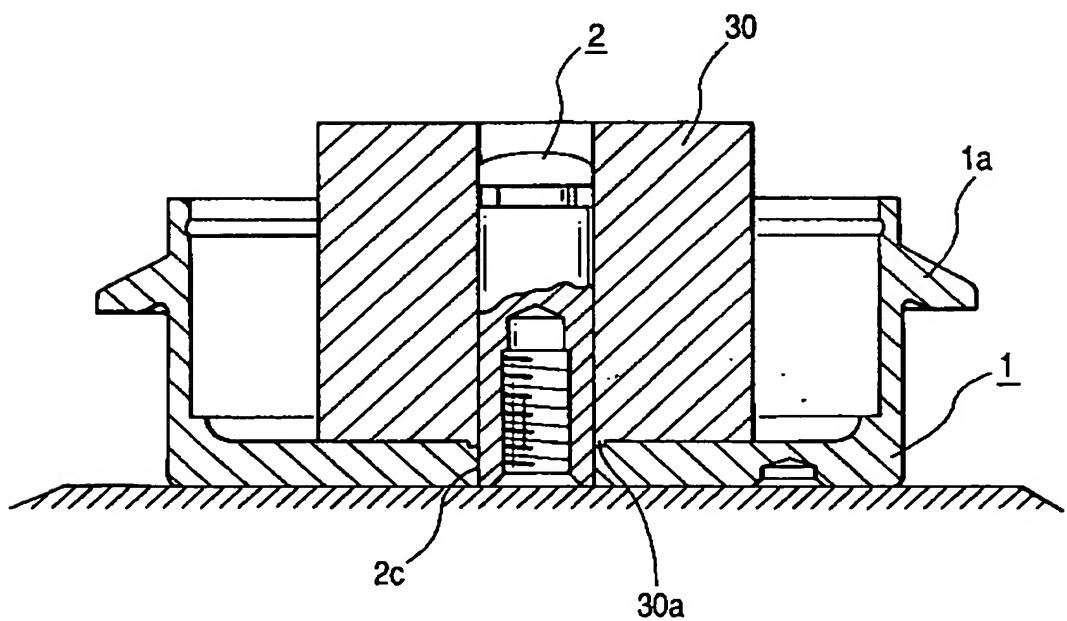


FIG. 5



SPINDLE MOTOR

BACKGROUND OF THE INVENTION

The present invention relates to a spindle motor, specially to a spindle motor for use in a disk drive motor using a dynamic pressure bearing.

As a spindle motor used in computerized devices, there are one using a ball bearing device to support the shaft as disclosed in the Japanese Published Examined Patent Application No. Hei 6-30554, and another one using a dynamic pressure bearing device as disclosed in the Japanese Published Unexamined Patent Application No. Hei 3-272318, which are widely known.

Specially, the latter dynamic pressure bearing device, being a noncontact type fluid bearing, provides a rotation of an extremely high accuracy, and is suitable for increasing the rotational speed of a rotor as well as effective in making revolution noises quiet.

The spindle motor using this type of dynamic pressure bearing is classified into two, namely, the fixed shaft type and the rotational shaft type. In case of the fixed shaft type, since the shaft is fixed on a base, the base is necessarily made thick and the structure becomes complicated; and therefore, it is difficult to thin the

spindle motor and to reduce the cost, which is disadvantageous.

In case of the rotational shaft type, a device to fix the shaft is not necessary and the structure is simplified compared with the fixed shaft type, which is suitable for thinning the spindle motor and reducing the cost. However, in case of the rotational shaft type, a countermeasure to prevent the slip-out of the spindle has to be applied. In the Japanese Published Unexamined Patent Application No. Hei 5-321928 is disclosed a structure in which a disc-like thrust plate larger than the diameter of the shaft is formed on the end of the shaft and thrust bearings are placed on both the upper and the lower ends of the thrust plate to thereby prevent the slip-out of the shaft.

Further, in case of the dynamic pressure bearing, the leakage of a lubricant effects a bad lubrication on the bearing, which shortens the life of the bearing. Furthermore, in case it is used in a magnetic disk drive, for example, a leaked lubricant smears the magnetic disk and the magnetic head, which possibly brings about a head crush. Therefore, it requires a measure to prevent the leakage of a lubricant. In order to prevent the leakage of a lubricant, the Japanese Published Unexamined Patent Application No. Hei 3-272318 provides a structure in which the inside of the bearing device is filled with a magnetic fluid being a

lubricant, and a magnetic fluid sealing is provided on both the ends of a radial bearing.

In the spindle motor using the conventional dynamic pressure bearing as in the latter case, to form the thrust bearing below the thrust plate will necessarily involve thickening the plate that faces the thrust plate. This will be a hindrance to thin the spindle motor. Further, as the movement of the shaft increases in the thrust direction due to a mechanical shock, the contact of a head for recording and reading to and from the magnetic disk will destroy the head; and therefore, the gap therebetween is necessary to be set with an extremely high accuracy. Accordingly, the machining accuracy of the parts will become strict, which invites increasing the production cost. Further, the foregoing structure catches the load in the thrust direction through the contact between the plate and the end face of the bearing, and the frictional resistance is high, which will invite a problem of increasing the power consumption of the motor.

SUMMARY OF THE INVENTION

The present invention has been made in view of the foregoing problems, and preferably the invention provides a spindle motor provided with a dynamic pressure bearing device, that can control the movement in the thrust

direction with a high accuracy and consumes a less power.

Preferably the invention provides a spindle motor provided with a thrust bearing device that facilitates the assembly work.

In a first aspect the spindle motor of the invention has a hub and a shaft concentrically disposed inside the inner circumference of a stator core, in which the shaft is borne by a bearing holding means through a bearing metal. And, the lower end of the shaft is made in a curved form and is borne by a pivot bearing of a bowl-like shaped thrust bearing fastened to the bearing holding means.

Preferably, the foregoing bowl-like shaped thrust bearing is fastened to a stepped part of the bearing holding means through a stopper plate, and the inner edge of the stopper plate is placed in a groove formed on the shaft to face thereto.

According to another aspect of the invention, the spindle motor has a hub and a shaft concentrically disposed inside the inner circumference of a stator core, and the shaft thereof is borne by a bearing holding means through a bearing metal, in which one end of the shaft is made in a curved form to be borne by a thrust bearing, a radial groove is formed on the shaft near the thrust bearing, and a stopper plate of which inner diameter part faces the groove on the

shaft, in noncontact therewith, of which outer part is fastened to the bearing holding means is provided.

Preferably, the foregoing stopper plate is annular, and has a plurality of axially movable tongue-shaped pieces on the inner diameter part thereof. And, the diameter of the foregoing inner diameter part is smaller than the outer diameter of the shaft and larger than the diameter of the bottom of the groove.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Fig. 1 is a sectional view of a spindle motor in one embodiment of the invention;

Fig. 2 is a plan view of a stopper plate in the embodiment;

Fig. 3 is an enlarged view of a major part that illustrates the coupling process of a hub and a shaft in the embodiment;

Fig. 4 is an enlarged sectional view of a part in Fig. 1; and

Fig. 5 is an illustration of a plastic coupling process of the hub and the shaft in the embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

One embodiment of the invention will be described with reference to Fig. 1. Fig. 1 is a sectional view of a spindle motor for a magnetic disk drive using a dynamic

pressure bearing. In the drawing, a bowl-like shaped hub 1 is formed to be incorporated with a flange 1a for mounting a magnetic disk on the peripheral thereof. A shaft 2 is provided with a center screw 2a for clamping the magnetic disk on the center thereof with a clamp not illustrated. The shaft 2 is made up with a separate part from the hub 1. After assembled with an engagement part 1b, the shaft 2 is concentrically fastened to the hub 1 by means of the widely known plastic deformation coupling or the like, and is rotatably supported by a cylindrical bearing housing (bearing holding means) 3 through a bearing (bearing metal) 4.

The lower end of the shaft 2 is made in a spherical or curved form, and is borne by a pivot bearing 5a of a bowl-like shaped thrust bearing 5 that is forced into and fixed to a stepped part 3a of the bearing housing 3. Further, an annular stopper plate 6 for controlling the movement of the shaft 2 in the thrust direction is disposed near the lower end of the shaft 2 in noncontact with a groove 2b to face thereto. The periphery of the stopper plate 6 is placed on the stepped part 3a of the bearing housing 3, and the stopper plate 6 is clamped and fixed at the same time when the thrust bearing 5 is fixed. On the bearing housing 3 is hermetically mounted a sealing member 7 on the upper part and an axially magnetized sealing magnet 8 between the

foregoing two bearings (bearing metals) 4. Inside a sealed fluid filling chamber 9 formed by the thrust bearing 5 is injected a magnetic fluid as the lubricant.

A stator core 10 made of laminated silicon steel plates has a coil 10a wound up, and is glued to be fixed on a cylindrical part 11a of a convex base 11. The stator core 10 is disposed with a specific gap between the periphery of the stator core 10 and the inner diameter of a rotor magnet 12 fastened on the inside of the hub 1. The rotor magnet 12 is forced into a stepped part 1c on the inner periphery of the hub 1, and thereafter fastened by a comparably soft metal ring 13 made of an aluminum, copper, or the like, which is placed in a groove provided on the inner periphery of the hub opening part.

The metal ring 13 is placed in the groove, and thereafter forced into the groove and crashed to be given a plastic deformation, whereby both the hub 1 and the rotor magnet 12 are strongly fastened. Further, the bearing housing 3 and the cylindrical part 11a of the base 11 are fixed by filling adhesives in a groove 11b formed between both of them. However, both may integrally be formed; and naturally, the adhesives become unnecessary in that case.

Next, the bearing device will be detailed with reference to Fig. 2, Fig. 3. Fig. 2 illustrates the shape of the stopper plate 6, and Fig. 3 is a sectional view to

illustrate the detail of the thrust direction control. The stopper plate 6 is formed of three tongue-shaped pieces 6b having slitty recesses 6a on the periphery, and it will deform in the thickness direction and plane direction of the plate owing to the recesses 6a. The stopper plate 6 is made of a stainless steel, for example, and a suitable heat treatment is applied so that the stopper plate 6 can obtain an elasticity. Alternatively, after the heat treatment, it is generally manufactured by the press working, etc. The minimum inner diameter d of the tongue-shaped piece 6b is slightly smaller than the outer diameter of the shaft 2, and it is larger than the diameter of the bottom of the groove 2b provided on the shaft 2.

In Fig. 3, the lower end plane of the tongue-shaped piece 6b faces with a gap δ to the wall of the groove 2b of the shaft 2. The dotted line 21 shows a state in which the shaft 2 is inserted from above and a part $2R$ of the spherical surface is brought into contact with an edge of the tongue-shaped piece 6b. The dotted line 21a shows a state in which the shaft 2 is further inserted and the tongue-shaped piece 6b is pressed and spread outward. When finally the shaft 2 is inserted to reach the solid line, the tongue-shaped piece 6b goes into the groove 2b owing to the elasticity produced by the recess 6a, thus forming the gap

δ.

Therefore, the shaft 2 cannot move more than the gap δ in the thrust direction. That is, the movement of the shaft 2 is controlled in the thrust direction. The position of the stator core 10 in Fig. 1 is set such that the magnetic force of the rotor magnet 12 exerts a downward thrust loading to the shaft 2, in the normal operation, and the shaft 2 rotates in noncontact with the tongue-shaped pieces 6b.

In this embodiment, after integrating the hub 1 and the shaft 2 and assembling the bearing device, the shaft 2 is inserted into the bearing device. Thereby, the assembly work of the spindle motor can be facilitated. If the stopper which can spread outward like the stopper plate 6 is not employed, the assembly work becomes difficult.

The bearing (bearing metal) 4 is made of a sintered metal to make a good circulation of the magnetic fluid, and it assumes the so-called porous structure. Although it takes a long time that the magnetic fluid sufficiently permeates into the porous structure, to apply the foregoing construction makes it possible to inject a specific quantity of the magnetic fluid into the structure, before the shaft 2 is inserted into the bearing 4, which is advantageous. To evacuate the air inside upon insertion, grooves are provided on the outer faces and end faces of the sealing magnet 8 and

the bearing (bearing metal) 4.

To cover after injecting the magnetic fluid, the construction as shown in Fig. 1 is inverted (made upside down), the magnetic fluid is injected from a small hole formed on the lower face of the thrust bearing 5, and the small hole is sealed with adhesives or a tape with adhesives.

Fig. 4 illustrates a section in which the coupling part of the hub 1 and shaft 2 is enlarged.

The coupling of the foregoing two parts is made as follows. The shaft 2 with a W-groove 2c formed on all around the upper part thereof is engaged with the engagement part 1b, then a part of the material of the hub 1 near the W-groove is pressurized vertically, thereby the material is given a plastic flow into the W-groove, and thus both of them are integrally coupled. To form the projection produced by the W-groove in an intermittent manner, or to form the same into a pyramidal shape will remarkably increase the coupling force in the direction of rotation, which is generally known.

Fig. 5 illustrates a plastic coupling method of the hub 1 and the shaft 2, in which the hub 1 is inverted on a flat mount. In the state that the shaft 2 is engaged with the engagement part 1b, a jig 30 with a pressing part 30a formed on the inner front end is inserted from inside, serving the shaft 2 as the guide, and a load is applied to

the hub 1 to thereby move a part of the material of the hub 1 into the W-groove 2c.

In case that the material of the shaft 2 is stainless bearing steel SUS420J2, heat treatment hardness HRC54, shaft diameter 3 mm, depth of groove 0.07 mm; the material of the hub 1 is SU5430, hardness HRC20, thickness 1 mm, gap of engagement 0.008 mm; the depth of the recess is about 0.1 mm; and the width of the recess is about 0.2 mm, to apply a load of about 200 kgf will strongly integrate both by the plastic flow.

As to the accuracy of the outer diameter of the shaft 2, for example, the range of allowance is necessary to be 1 μ m, and the error of roundness is necessary about 0.1 μ m; however, the method of integrating the hub 1 and the shaft 2 by cutting is almost impossible to achieve this level of accuracy on a mass production. To manufacture the shaft 2 and the hub 1 separately as in this invention will easily enhance the machining accuracy of each part.

The invention, taking on a structure in which the thrust bearing of the shaft is formed in a bowl-like shape and the lubricant can be filled in the chamber made by the thrust bearing, provides a spindle motor containing the dynamic pressure bearing structure which will not block the oil flow although the construction is rather simple.

In the invention, the groove in which the thrust direction controlling member is inserted is formed on the shaft, and the front end of the shaft is formed in a curved plane to function as the thrust bearing. Thereby, the spindle motor according to the invention will reduce the friction resistance in the axial direction, enhance the accuracy of rotation, and consume a less power.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

What is claimed is:

1. A spindle motor having a hub and a shaft being concentrically disposed inside the inner circumference of a stator core and the shaft being borne by a bearing holding means through a bearing metal, the lower end of the shaft is made in a curved form and is borne by a pivot bearing of a bowl-like shaped thrust bearing fastened to the bearing holding means.
2. A spindle motor as claimed in Claim 1, wherein the bowl-like shaped thrust bearing is fastened to a stepped part of the bearing holding means through a stopper plate, and the inner edge of the stopper plate is placed in a groove formed on the shaft to face thereto.
3. A spindle motor having a hub and a shaft being concentrically disposed inside the inner circumference of a stator core and the shaft being borne by a bearing holding means through a bearing metal, one end of the shaft is made in a curved form to be borne by a thrust bearing, a radial groove is formed on the shaft near the thrust bearing, and a stopper plate whose inner diameter part faces the groove on the shaft in noncontact therewith, and whose outer part is fastened to the bearing holding means is provided.

4. A spindle motor as claimed in Claim 3, wherein the stopper plate is annular, and has a plurality of axially movable tongue-shaped pieces on the inner diameter part thereof, in which the diameter of the inner diameter part thereof is smaller than the outer diameter of the shaft and larger than the diameter of the bottom of the groove.

5. A spindle motor using a dynamic pressure bearing comprising:

a motor shaft,

a hub provided at said motor shaft,

a motor shaft bearing device having said dynamic pressure bearing and a thrust bearing, said thrust bearing being provided at an opposite end of said hub and having a bowl-like shape, and

a lubricant provided and sealed in space formed by said bowl-like shape thrust bearing.

6. A spindle motor comprising:

a motor shaft,

a hub fixed to said motor shaft,

a motor shaft bearing device having a radial bearing and a thrust bearing, said thrust bearing being provided at an opposite end of said hub,

wherein said motor shaft is provided with a groove thereon

near said thrust bearing, and
a stopper fixed to said motor shaft bearing device, an inner
part of said stopper engaging with and being positioned
inside said groove in noncontact therewith, and said inner
part of said stopper being able to move in the opposite
direction of said groove when said motor shaft is installed
in said motor shaft bearing device.

7. A manufacturing method of spindle motor comprising:
fixing a motor shaft to a hub, said motor shaft being
provided with a groove thereon,
providing a motor shaft bearing device having a radial
bearing, a thrust bearing and a stopper, wherein said thrust
bearing being provided at an opposite end of said hub when
said spindle motor is assembled, and an inner part of said
stopper being able to move in the opposite direction of said
groove when said motor shaft is installed in said motor shaft
bearing device, and
installing said motor shaft fixed to said hub in said motor
shaft bearing device so that said inner part of said stopper
engages with and is positioned inside said groove in
noncontact therewith.



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Claims searched: 1,2

Examiner: John Cockitt
Date of search: 29 April 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H2A [AKJ1, AKJ1A]

Int Cl (Ed.6): H02K [05/167]

Other: ONLINE: EPODOC, WPI, JAPIO; OPTICS [H2A]

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	GB2202387A SONY - see thrust bearing	1 at least
X	GB1009372A SPINDEL - see thrust bearing assembly 6	1 at least
X	US4955791A PAPST - see thrust bearing assembly 8	1 at least
A	US5291358A MATSUSHITA - example of known art - relevant to common matter	(1,3,6,7)

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.

& Member of the same patent family

A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.

E Patent document published on or after, but with priority date earlier than, the filing date of this application.